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ABSTRACT

Assuming that some handwriting will be necessary in the computer age, questions remain as to the instructional techniques that facilitate learning in handwriting, whether the cost and time required to teach two forms of writing can be justified, and which form is learned more easily and is better suited for use in a technological age. Effective instruction must be based on recognition that handwriting is a perceptual motor skill. Principles of instruction that are important to teaching handwriting are based on theories of perceptual learning, and research supports the use of perceptual learning techniques. Characteristics of computer assisted instruction (CAI) include individualization of the rate of learning, adjustment of difficulty, feedback, and reinforcement. Comparison of the instructional techniques shown to be important in perceptual learning in handwriting with the capabilities of CAI suggests that computers have the potential to facilitate learning of handwriting. Although the development of CAI in handwriting is in the early stages, available research supports the conclusion that carefully designed computer-based programs of instruction can be of value for some, if not all, learners. It also appears that continued research in analysis of handwriting processes and products can lead to refinement in forms taught and materials used for writing by children and adults. (Recommendations for the development of handwriting programs involving CAI are included.) (HTH)

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Handwriting Instruction for a High-Tech Society: Will Handwriting Be Necessary?

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Handwriting Instruction for a High-Tech Society

Will Handwriting Be Necessary?

High-tech has become a high frequency word. In educational journals, the daily newspaper, television specials, and commercials for everything from agriculture to word processing, high-tech is the buzz word. We are forewarned that if not now, in the very near future, agriculture, communications, education, entertainment, finance, government, health care, manufacturing, merchandising, public services, and transportation will all be computer-based. Given the pervasiveness of technology, one wonders about the necessity for future generations to have a handwriting system.

Interestingly, the advent of both the printing press and typewriter led to claims that handwriting would cease to be a necessary skill for adults. Neither claim proved true. As early as 1925, Benbow concluded that "it is probable that longhand will persist--at least until inventions have made the typewriter as easy to carry as a pen or pencil and within financial reach of all" (p.54).

More recently, Templin (1960, 1963) conducted a survey of

handwriting practices of 1946 high school graduates from 20 eastern communities 10 years after their graduation. The 454 respondents--195 men and 259 women--included professional, white-collar, and blue-collar workers. They reported that they produced an average of slightly less than nine pages of handwritten material per week, based on an estimate of what they could write on an 8 1/2 by 11 inch paper. Professional workers averaged 17.7 pages compared with about 4 pages for blue-collar workers. Rank ordering of the four preferred tools for men was: pencil (50.3%), ballpoint pen (28.7%), fountain pen (17.9%), and typewriter (2.6%). For women rankings were: ballpoint pen (36.7%), fountain pen (29.3%), pencil (26.6%), and typewriter (6.6%).

Function or purpose seemingly influenced the choice of writing form. Handwriting was used for making out checks, handling social correspondence, filling in forms, preparing shopping lists, jotting down notes, and making rough drafts. The latter uses were reported by professional and white-collar workers, even when they had access to secretarial services. Templin (1960) concluded that while the typewriter and printing press have gradually supplanted handwriting for making permanent records, "there is strong evidence to support the belief that all the children now in school will need handwriting in their business and social lives for many years to come" (p. 164).

That statement was made in 1960. What about 1985 and beyond? While I have been unable to find recent studies of the impact of

technology on the need for handwriting, several trends are evident. Computer access will increase in homes, classrooms, libraries, and workplaces. Cost will, no doubt, continue to decrease. Similarly, portability will continue to increase. Word-processing programs for children and adults will be widely used in writing. Yet, it is difficult to foresee a time when all writing will be done via computer or other technologies.

If we assume that some handwriting will be necessary, if only for signatures and immediate, non-permanent jottings, several questions remain. What instructional techniques facilitate learning in handwriting? Can computer-assisted instruction (CAI) provide instructional help for some or all learners? Can the instructional time and cost required to teach two handwriting forms be justified? What form is learned most easily and is best suited for use in a technological age?

What Instructional Techniques Facilitate Learning in Handwriting?

Traditionally, handwriting has been taught as a motor skill. Emphasis has been given to copying, tracing, and exercises and drills (Addy & Wylie, 1973: Herrick & Okada, 1963), all of limited value in perceptual learning. Effective instruction must be based on recognition that handwriting is a perceptual-motor skill. To learn to write the the child must form a mental representation of lower-case and capital letter forms, numerals, punctuation marks, and general procedures of writing including size, spacing, alignment, straightness or slant, joining of

strokes, and line quality. Accurate perceptual representations are necessary for the development of legible, fluent writing.

Through an analysis of theories of perceptual learning (Gibson, 1953, 1963, 1969; Gibson, Gibson, Pick, & Osser, 1962; Gibson & Levin, 1975; Gibson, Osser, Schiff, & Smith, 1963; Rock, 1975, 1983), I have identified principles of instruction which are important to the teaching of handwriting (Furner, 1967, 1969a, 1969b, 1970, 1983, 1985), as follows:

1. Perceptual learning in handwriting results in an imaginal, sensory-motor, and/or conceptual representation of the form and formational process. This developmental process is facilitated by active discovery and decision-making by the learner.

2. Perceptual set or recognition of a specific problem or uncertainty facilitates perceptual learning and organization.

3. Multiple exposures to the form through multiple modes (visual, auditory/verbal, and kinesthetic) enhance perceptual learning, especially when attention is focused on discovery of specific features during successive exposures.

4. Guided observation of the formational process, rather than just seeing the still model facilitates discovery of significant features.

5. Verbal labels or terms can aid differentiation of significant or contrastive features, especially if letters having common formational features are taught together.

6. Verbal description by the learner facilitates both imaginal and conceptual representation of the form and the

formational process.

7. The verbalization or visualization of the form or the movement necessary to produce the formation can serve as a basis for practice and self-evaluation.

8. Self-corrective feedback through comparison of one's own model with the desired one to identify progress and needed improvements reinforces accurate and lasting percepts of both form and formational processes and growth in motoric abilites.

These principles served as the foundation for a handwriting method which I developed and assessed in a six-year longitudial study involving children from first grade through sixth grade. Data reported elsewhere (Furner, 1967, 1969a, 1969b, 1970, 1983, 1985) support the general conclusion that the experimental, perceptually-based methodology which involved multi-sensory stimualtion, verbalization of procedures, and self-evaluation was effective as a means of instruction. In general, children using this method were able to write with comparable or superior quality, with more correct formational procedures, and with speed adequate to meet writing demands.

Several recent studies have examined the effectiveness of one or more of these instructional techniques in handwriting. Tracing and copying (Askov & Greff, 1975; Hirsch & Niedermeyer, 1973) were examined along with techniques designed to facilitate perceptual learning. These included copying with and without discrimination training (Hirsch & Niedermeyer, 1973; Williams, 1975); copying with and without demonstration (Søvik, 1976), use

of verbal instructions (Kirk, 1981) and/or student description (Hayes, 1982); self-evaluation with and without visual and verbal feedback, rewriting, and/or reinforcers (Helwig, 1976; Helwig, Johns, Norman, & Cooper, 1976; Johns, 1977; Johns, Trap, & Cooper, 1977; Trap, 1977; Trap, Milner-Davis, Joseph, & Cooper, 1978); and use of dynamic versus static models (Søvik, 1979; Wright & Wright, 1980). A more complete review of these studies is provided elsewhere (Furner, 1983, 1985).

Together, these studies support use of perceptual-learning techniques. They show that tracing exercises were not effective in developing letter formation ability, since they emphasize motor skills and do not involve active decision-making. Discrimination training, which utilized only perceptual skills, facilitated matching tasks, but not production tasks. Simple copying appeared to facilitate production of instructed letters, but demonstration or discrimination training was necessary for transfer to uninstructed letters. Demonstration, especially when combined with verbal instructions, was superior to either instructional procedure alone. Enhanced stimulation was necessary for discovery of the rules of formation. A similar rationale explains the effectiveness of dynamic, rather than still models and of self-verbalization and self-evaluation techniques, especially those combining verbal and visual feedback with rewriting or reinforcement.

Can CAI Facilitate Instruction in Handwriting?

CAI involves interaction of the learner with the computer to

teach new skills or information or for practice. Characteristics of CAI include individualization of the rate of learning based either on computer-analysis of responses or by the learner, structuring of learning to fit both the content and the learner's needs, adjustment of the level of difficulty, prompting to assure success, provision of feedback and reinforcement, and informing the learner of the amount and type of instruction needed to meet a defined level of mastery (Hofmeister, 1984; Johansen & Tennyson, 1983; Macleod & Overheu, 1977).

Recent advances in hardware offer varying modes for presentation, student response, and provision of feedback. In addition to the keyboard, CRT (cathode ray tube), and printer; peripherals now include light pens, touch panels, graphics tablets and pens, joy sticks, voice synthesizers and recognition devices, optical scanners, tape recorders, videotape and videodisks, and television display screens (Alessi & Trollip, 1985).

Computer-Based Research in Handwriting

Comparison of the instructional techniques shown to be important in perceptual learning in handwriting with the capabilities of computer-based instruction suggest that CAI has potential to facilitate learning in this basic literacy skill. Yet, at present there is no commercially available courseware for handwriting and surprisingly little research in the area. Research using CAI to teach handwriting includes a series of Australian studies designed to teach basic skills to special

education students (Lally, 1981, 1982; Lally & Macleod, 1982; Macleod & Overheu, 1977; Macleod & Proctor, 1979) and a study using the computer to teach the Arabic writing system to English-speaking adults (Abboud, 1972).

The Australian National University researchers recognized the limitations of tracing and copying in handwriting instruction. They cited the need for learners to make active decisions, to utilize accurate and consistent motor patterns, to produce correct responses, and to receive feedback which promotes learning (Lally & Macleod, 1982). These principles were incorporated in computer-based handwriting exercises teaching signatures and lower-case manuscript letters and numerals. Equipment included a display screen on which fine detail is drawn by the computer and a digitizer pen, the size and shape of a thick pencil. The computer calculates the position of the pen from the lengths of two fine strings attached to the pen tip which pass through eyelets above the display. A switch inside the pen indicates it up/down position. Since the beginning of the research in 1974, the position of the display screen has been modified from an angle 20° from vertical (Macleod & Procter, 1979) to one angled about 20° above the horizontal with the leading edge at desk height (Lally, 1982; Lally & Macleod, 1982). The horizontal position would seemingly facilitate transfer to writing on paper.

CAI capabilities can be illustrated by describing the instructional sequence of a 4-week study (Lally, 1982) attempting

to improve formation of lower-case manuscript letters and numerals by 9 mentally retarded boys, aged 9-16 years. Mean IQ for these students was 61, with a range from 41-81 (SD=14). Lower-case manuscript letters and the numerals 0-9 were used as the test and training materials. Instruction involved four 20-minute individual sessions per week, or a total of about 5 hours. For instruction, letters were separated into individual files according to formational features. Numerals were presented in various order on five different files.

The instructional procedure used involved a series of lessons in which the learner was first familiarized with the display screen and pen through drawing and tracking exercises. In the tracking exercises the cursor-box was drawn under the pen tip. A small blinking light indicated where the pen tip should be. When the spot was located within the cursor-box and the pen pressed down, the blinking spot moved along the track, thickening the line as as it went, until it reached a point just outside the leading edge of the cursor-box. These exercises required the child to complete the series of strokes required for alphanumeric forms. Records of speed and accuracy of tracking were recorded.

This study assessed the effects of three cursor-box sizes on improvement in handwriting: large (15mm square), small (5mm square), and large reducing to small in 1mm steps as the student reached an asymptote in terms of speed and accuracy of tracking. Each student was assigned to two training conditions, one for letters and another for numerals, dependent on initial

handwriting samples. Alternative training conditions for each student were given on successive days. The same number of practice exercises was given in each condition for each student. In these exercises partial rather than complete outlines of the numeral or letter to be tracked were presented. The use of partial visual cues encouraged the student to make active decisions drawing on perceptual memory of the letter or numeral shape to be formed. However, since line filling ceased and the blinking spot acted as a prompt if the child moved the pen outside the cursor-box, practice of erroneous formations was limited.

Trained raters judged improvement between initial and final samples of the 26 letters and 10 numerals on a 10-point scale. Significant differences were found in improvement based on the size of cursor-box used in training. Greatest improvement was found among students using the reducing cursor-box, followed by those using the small size. There was no overall improvement for the students using the large cursor-box. The large error tolerance permitted these students to succeed while using gross and relatively inaccurate hand and arm movements in tracking. The small cursor-box required finer hand-finger movements. However, the initial task difficulty resulted in back-tracking movements of the pen to keep the blinking spot in the cursor-box, rather than smooth continuous stroking. Lally (1982) suggested that improvement in the group using the reducing cursor-box resulted from:

> the gradual shaping of finer and finer hand/finger movements through successively decreasing the degree of tolerance allowed for successful tracking. Furthermore, this technique (which incorporated the use of partial visual cues, emphasis on speed and accuracy and provision of nondistracting, task oriented feedback), made it easier for the learner to internalize those control functions which are responsible for fluent handwriting. (p. 403)

Another important feature of this approach was the use of demonstrated movement as the blinking spot moved along the track. The amount of demonstrated movement was gradually decreased as cursor-box size was decreased, requiring the child to rely on perceptual memory, rather than external cues. Since reduction in cursor-box size was determined by success in speed and accuracy in tracking, individualization in both task demand and in the nature of feedback was provided. Successful tracking required use of the unique sequence of strokes for each form. Also, the computer model of the form was shown, rather than the child's actual pen movements. Since accuracy in the model was maintained, visual feedback facilitated perceptual learning.

In the course of this research, the positve effects of CAI in structuring learning experiences has been documented, not only for handwriting but for other basic skills. Apparatus other than the traditional keyboard and visual display screen was used for all instruction. For example, in word recognition tasks, computer synthesized voice was utilized in conjunction with a

touch sensitive display screen, while in work with eye-hand coordination and visual and auditory memory, a button box proved useful (Lally & Macleod, 1982; Macleod & Overheu, 1977).

As noted above, I have identified only one other study utilizing CAI to teach handwriting skills, specifically the Arabic writing system to English-speaking adult students. Use of CAI was justified because it permits "many more options for individualizing instruction, immediate feedback, management of a complete system of events of great complexity, and the capability to control a variety of complex display and response entry devices" (Abboud, 1972, p. 196). Learning tasks included visual discrimination, writing, and oral reading. Equipment included the CRT for display of cursive forms, an image projector for display of printed forms, a random access voice unit, a keyboard to enter responses in English, a grease pencil to write on the face of the CRT, and a light pen to register a choice of answers. Also used were the student's vocal responses and a notebook for written responses.

Compared with audio-lingual and programmed instruction used at two other universities, students using the CAI approach used only 40% of the time taken by the other groups and achieved significantly superior writing performance. Oral reading and visual discrimination grades were comparable to the other groups. Evaluation questionnaires indicated that the students enjoyed the program, felt it speeded up learning, and responded to individual needs.

In addition to these computer-based instructional studies, there are a few studies which utilize the computer to analyze the development of graphic abilities and prefarences in directional patterns in children and adults (Teulings & Thomassen, 1979; Thomassen & Teulings, 1979), to analyze muscular patterns required in specific graphic formations (Hollerbach, 1979), and to analyze features of signatures and writing samples for security and forensic purposes (Ansell, 1979; Watson and Pobgee, 1979).

Recommendations for the Future

Although the development of CAI in handwriting is in early stages, available research supports the conclusion that carefully designed, computer-based programs of instruction can be of value for some, if not all, learners. Further, it appears that continued research in analysis of handwriting processes and products can lead to refinement in forms taught and materials used for writing by children and adults.

I will conclude with several recommendations for the development of handwriting programs involving CAI:

1. Further research is needed concerning the effectiveness of CAI in handwriting for all types of learners. Studies should also be designed to examine ways in which teachers can most effectively integrate computer-based instruction with other strategies.

2. Since handwriting is a perceptual-motor skill, principles of perceptual learning theory should be utilized in developing

CAI courseware in handwriting.

3. The interactive capabilities of CAI should be used to facilitate active dicsovery and decision-making by learners. Also, multiple exposures to the form or formation being learned involving visual, auditory/verbal, and kinesthetic modes should be used.

4. Handwriting courseware should incorporate research-supported instructional techniques including use of dynamic models, provision of both verbal and visual input, learner interaction through both verbal and kinesthetic response, and provision of both verbal and visual feedback. To do this, courseware will need to utilize a variety of peripherals such as graphics tablets and pens, voice synthesizers and recognition devices, and videodisk or videotape.

5. Courseware should facilitate self-evaluation and identification of needed improvements, by permitting the child to compare his/her form and formational process with the desired one as a basis for future practice. In early stages of learning, a prompt could be given if the child does not use the correct formational procedure. Later, self-analysis could be guided by projecting the child's formation over the desired one. The child could then use a light pen or touch sensitive screen to identify needed improvements. A buzzer or light cue could also signal the needed improvement. Use of verbal descriptions or questions could aid self-analysis, thus heightening individualization of instruction.

6. Only the manuscript form of handwriting should be taught in instructional programs. There are several reasons for this recommendation:

a. Manuscript writing has been documented to be the best form for initial learning because it is easier perceptually. In manuscript writing the unit of perception is the stroke or letter rather than the word, as in cursive. Also, closed figures and forms which are in vertical orientation to the baseline are perceived earlier and more accurately than irregular forms and those which are in diagonal relationship to the baseline. Diagonals have been shown to be difficult for children as old as 7-years (Gibson, 1969; Gibson & Levin, 1975).

b. Because of its greater similarity to print, use of the manuscript form has been shown to support initial reading. As societal use of computer-based communication systems increases, early exposure to computer print will also increase. Further, as CAI is used instructionally across the curriculum, the greater similarity of forms will make use of the manuscript form even more crucial.

c. Manuscript writing is an accepted form and is used by many adults for both occupational and personal purposes (Groff, 1964; Templin, 1963). Manuscript writing of intermediate grade children and adults, having equal practice in the form, is as or more legible than cursive and can be written with equal speed (Andersen, 1965; Askov, Otto, & Askov, 1970).

d. Instructional time can be saved by teaching only one

handwriting form. Since the introduction of manuscript writing in the United States in 1921, there has been no justification for time spent teaching a dual form. With the increased use of computer-based systems of communication, the inefficency of this practice will be the more striking. After developing manuscript as a handwriting form through which children can discover principles of writing and print, instructional time in an already overcrowded curriculum should be devoted to purposeful written expression. In the short term, it would make more sense to make the transition from manuscript writing to keyboard skills rather than to cursive, although advances in voice activated input systems may soon make that unnecessary.

In short, it appears that handwriting will have a place in a high-tech society--and even that well-designed courseware can facilitate acq isiton of the skill--leaving greater amounts of instructional time for writing, whether by hand or technologic means.

Bibliography

Abboud, V. C. (1972). The computer as an instructional device for the Arabic writing system. Computers and the Humanities, 6, 195-207.

Addy, P., & Wylie, R. E. (1973). The "right" way to write. Childhood Education, 49, 253-254.

Alessi, S. M., & Trollip, S. R. (1985). Computer-based instruction: Methods and development. Englewood Cliffs, NJ: Prentice Hall.

Anderson, D. W. (1965) Handwriting research: Style and practice. Elementary English, 42, 115-125.

Ansell, M. (1979). Handwriting classification in forensic science. Visible Language, 13, 239-251.

Askov, E., & Greff, N. (1975). Handwriting: Copying versus tracing as the most effective type of practice. Journal of Educational Research, 69, 96-98.

Askov, E., Otto, W., & Askov, W. (1970). A decade of research in handwriting: Progress and prospect. Journal of Educational Research, 64, 100-111.

Benbow, A. E. (1925). Public school writing. Journal of Educational Method, 5, 52-56.

Furner, B. A. (1[illegible]). The development of a program of instruction for beginning handwriting emphasizing verbalization of procedures to increase perception and an analysis of the effectiveness of this program through comparison with a commercial method (Doctoral dissertation,

University of Iowa, Iowa City, 1967). Dissertation Abstracts International, 28, 389A-390A.

Furner, B. A. (1969a). The perceptual-motor nature of learning in handwriting. Elementary English, 46, 886-894.

Furner, B. A. (1969b). Recommended instructional procedures in a method emphasizing the perceptual-motor nature of learning in handwriting. Elementary English, 46, 1021-1030.

Furner, B. A. (1970). An analysis of the effectiveness of a program of instruction emphasising the perceptual-motor nature of leeaning in handwriting. Elementary English, 47, 61-69.

Furner, B. A. (1983). Developing handwriting ability: A perceptual learning process. Topics in Learning and Learning Disabilities, 3(3), 41-54.

Furner, B. A. (1985). The teaching of handwriting: A perceptual learning metholology. Manuscript in preparation.

Gibson, E. J. (1953). Improvements in perceptual judgments as a function of controlled practice or training. Psychological Bulletin, 50, 401-413.

Gibson, E. J. (1963). Perceptual development. In H. W. Stevenson, J. Kagan, & C. Spiker (Eds.), Child Psychology, Sixty-second Yearbook of the National Society for the Study of Education, Part 1 (pp. 144-195). Chicago: University of Chicago Press.

Gibson, E. J. (1969). Principles of perceptual learning and development. New York: Appleton-Century-Crofts.

Gibson, E. J., Gibson, J. J., Pick, A. D., & Osser, H. (1962). A developmental study of the discrimination of letter-like

forms. Journal of Comparative and Physiological Psychology, 55, 897-906.

Gibson, E. J., & Levin, H. (1975). The psychology of reading. Cambridge: The MIT Press.

Gibson, E. J., Osser, H., Schiff, W., & Smith, J. (1963). An analysis of critical features of letters, tested by a confusion matrix. In H. Levin; E. J. Gibson; A. L. Baldwin; J. J. Gibson; C. F. Hockett; H. N. Ricciuti; & G. J. Suci (Eds.), A basic research program on reading. (Cooperative Research Project No. 639). Ithaca, NY: Cornell University and U. S. Office of Education.

Groff, P. J. (1964). Preference for handwriting style by big business. Elementary English, 41, 863-864, 868.

Hayes, D. (1982). Handwriting practice: The effects of perceptual prompts. Journal of Educational Research, 75, 169-172.

Helwig, J. J. (1976). Measurement of visual-verbal feedback on changes in manuscript letter formation. Dissertation Abstracts International, 36, 5196A. (Univeristy Microfilms No. 76-3448)

Helwig, J. J., Johns, J. C., Norman, J. E., & Cooper, J. O. (1976). Brief technical report: The measurement of manuscript letter strokes. Journal of Applied Behavior Analysis, 9, 231-236.

Herrick, V. E., & Okada, N. (1963). The present scene: Practices in the teaching of handwriting in the United States--1960. In V. E. Herrick (Ed.), New horizons for research in handwriting: Report of the invitational conference on research in

handwriting held at the University of Wisconsin, October, 1961 (pp. 17-38). Madison: University of Wisconsin Press.

Hirsch, E., & Niedermeyer, F. C. (1973). The effects of tracing prompts and discrimination training on kindergarten handwriting performance. Journal of Educational Research, 67, 81-86.

Hofmeister, A. (1984). Microcomputer applications in the classroom. New York: Holt, Rinehart and Winston.

Hollarbach, J. (1979). A competence model for handwriting. Visible Language, 13, 252-264.

Johansen, K. J., & Tennyson, R. D. (1983). Effect of adaptive advisement on perception in learner-controlled, computer based instruction using a rule-learing task. Educational Communication and Technology Journal, 31, 226-236.

Johns, J. C. (1977). The effects of training, self-recording, public charting, and group contingencies on manuscript handwriting legibility. Dissertation Abstracts International, 37, 4824A. (University Microfilms No. 77-2425)

Johns, J. C., Trap, J., & Cooper, J. O. (1977). Technical report: Students' self-recording of manuscript letter strokes. Journal of Applied Behavior Analysis, 10, 509-514.

Kirk, U. (1981). The development and use of rules in the acquisition of perceptual motor skill. Child Development, 52, 299-305.

Lally, M. (1981). Computer-assisted instruction for the development of basic skills with intellectually handicapped

school children. Canberra: Australian Education Research and Development Committee. (ERIC Document Reproduction Service No. ED 222 170)

Lally, M. (1982,). Computer-assisted handwriting instruction and visual/kinaesthetic feedback processes. Applied Research in Mental Retardation, 3, 397-405. (Also ERIC Document Reproduction Service No. ED 216 687)

Lally, M., & Macleod, I. (1982). Development of skills through computers: Achieving an effective, enjoyable learning enviornment. Impact of Science on Society, 32, 449-460.

Macleod, I., & Overheu, D. (1977). Computer aided assessment and development of basic skills. The Exceptional Child, 24, 18-35.

Macleod, I., & Procter, P. (1979). A dynamic approach to teaching handwriting skills. Visible Language, 13, 29-42.

Rock, I. (1975). An introduction to perception. New York: Macmillan.

Rock, I. (1983). The logic of perception. Cambridge, MA: Bradford Books, The MIT Press.

Søvik, N. (1976). The effects of different principles of instruction in children's copying performance. Journal of Experimental Education, 45, 38-45.

Søvik, N. (1979). Some instructional parameters related to children's copying performance. Visible Language, 13, 314-330.

Templin, E. M. (1960). How important is handwriting today? Elementary School Journal, 61 (3), 158-164.

Templin, E. M. (1963). The legibility of adult manuscript,

cursive, or manuscript-cursive handwriting styles. In V. E. Herrick (Ed.), New horizons for research in handwriting: Report of the invitational conference on research in handwriting held at the University of Wisconsin, October, 1961 (pp. 185-206). Madison: University of Wisconsin Press.

Teulings, H. H. M., & Thomassen, A. J. W. M. (1979). Computer-aided analysis of handwriting movements. Visible Language, 13, 218-231.

Thomassen, A. J. W. M., & Teulings, H. H. M. (1979). The development of directional preference in writing movements. Visible Language, 13, 299-313.

Trap, J. J. (1977). Manuscript proficiency as an indication of readiness for cursive handwriting and learner verification of evaluative overlays for transition cursive letter strokes. Dissertation Abstracts International, 38, 2547A. (University Microfilms No. 77-24,722)

Trap, J. J., Milner-Davis, P., Joseph, S., & Cooper, J. O. (1978). The effects of feedback and consequences on transitional cursive letter formation. Journal of Applied Behavior Analysis, 11, 381-393.

Watson, R. S., & Pobgee, P. J. (1979). A computer to check signatures. Visible Language, 13 232-238.

Williams, J. (1975). Training children to copy and to discriminate letterlike forms. Journal of Educational Psychology, 67, 790-795.

Wright, C. D., & Wright, J. P. (1980). Handwriting: The

effectiveness of copying from moving versus still models. Journal of Educational Research, 74, 95-98.